REMARKS

Applicant has studied the Office Action dated April 11, 2001 and has made amendments to the claims. It is submitted that the application, as amended, is in condition for allowance. By virtue of this amendment, claims 1-16 and 25-31 are pending. Claims 22-24 have been canceled without prejudice. Claims 1, 7, 11, 12, and 15 have been amended, and new claims 25-31 have been added. Reconsideration and allowance of the pending claims in view of the above amendments and the following remarks are respectfully requested.

The Examiner stated that the IDS filed November 13, 1998 failed to comply with 37 C.F.R. § 1.98(a)(3) because a concise explanation of the relevance of the EP 0 491 976 A1 reference was not provided. Applicant is in the process of obtaining a concise explanation of the relevance of this non-English language reference, and will forward it to the Examiner as soon as it is available. Applicant respectfully requests that the Examiner consider the reference after the concise explanation of its relevance is provided.

The drawings were objected to because Figure 1 was not designated by a legend such as "Prior Art". Please replace Figure 1 filed with the application with the enclosed drawing, which has changes marked in red. Figure 1 has been labeled "Prior Art" as requested by the Examiner. In light of this amendment, it is submitted that the objection to the drawings should be withdrawn. Additionally, the Official Draftsperson objected to the drawings. Applicant requests that submission of corrected formal drawings be deferred until after allowance.

The specification was objected to for incorporating essential material by reference to a foreign patent application. Applicant has amended the specification so that the foreign patent application from which the present application claims priority under 35 U.S.C. § 119 is no longer incorporated by reference. In light of this amendment, it is submitted that the objection to the specification should be withdrawn.

Claims 15 and 16 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Applicant has amended claim 15 as suggested by the Examiner, and submits that all pending claims are now clear and definite. Therefore, it is respectfully submitted that the rejection of claims 15 and 16 under 35 U.S.C. § 112, second paragraph, should be withdrawn.

Claims 1-7, 10, and 11 were rejected under 35 U.S.C. § 102(b) as being anticipated by Beinglass (U.S. Patent No. 5,141,892). Claim 8 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass in view of Alspector et al. (US Patent No. 4,441,249). Claims 9 and 14 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass in view of Alspector et al. and Wang et al. (U.S. Patent No. 5,646,061). Claims 12, 13, 15, and 16 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass. These rejections are respectfully traversed.

The present invention is directed to in-situ deposition and doping methods for polycrystalline silicon layers that prevent the dopant from reaching the surface during a subsequent thermal treatment. One preferred embodiment of the present invention provides an in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device. According to the method, a first intermediate layer of in-situ doped polycrystalline silicon is grown with a first thickness and a first doping level, and a second additional layer of polycrystalline silicon is grown with a second thickness and a second doping level that is lower than the first doping level. The first thickness is substantially greater than the second thickness so that the average doping level resulting from a summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of doping atoms from the first intermediate layer to the second additional layer.

Because the second additional layer of polycrystalline silicon with a lower doping level is provided, the dopant is prevented from reaching the surface during a subsequent thermal treatment. Further, because the doped first intermediate layer is substantially thicker than the less

doped (or non-doped) second additional layer, the average doping level resulting from the summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of the dopant from the first intermediate layer to the second additional layer in the thermal treatment. See specification at 6:9-20; 7:17-20.

The Beinglass reference discloses a process for depositing a highly doped polysilicon layer on a stepped surface so as to achieve enhanced step coverage. However, Beinglass does not disclose an in-situ deposition and doping method for a polycrystalline silicon layer in which a first intermediate layer of in-situ doped polycrystalline silicon is grown with a first thickness and a first doping level, and a second additional layer of polycrystalline silicon is grown with a second thickness and a lower second doping level, with the first thickness being substantially greater than the second thickness so that the average doping level is not significantly changed by diffusion of doping atoms, as is recited in amended claim 1.

Similarly, Beinglass does not disclose an in-situ deposition and doping method for a polycrystalline silicon layer in which a first intermediate layer of in-situ doped polycrystalline silicon is grown with a first thickness, a second additional layer of substantially non-doped polycrystalline silicon is grown with a second thickness, and a re-oxidation thermal treatment is performed to diffuse dopant from the first intermediate layer to the second additional layer, with the first thickness being substantially greater than the second thickness so that the average doping level is not significantly changed by diffusion of dopant in the re-oxidation thermal treatment, as is recited in amended claim 15.

The Beinglass reference discloses a process for depositing a doped polysilicon layer by depositing a series of thin polysilicon layers that are alternately doped and non-doped. A thermal annealing step is then performed to distribute the dopant in the doped layers throughout all of the polysilicon layers in a uniform, homogeneous way. In the process of Beinglass, both doped polysilicon layers and non-doped polysilicon layers are repeatedly deposited to a thickness of between 400 and 800 Angstroms so as to sum to a total thickness of between 1500 and 4000 Angstroms. Thus, Beinglass discloses depositing doped and non-doped polysilicon layers having the same or substantially similar thicknesses.

In contrast, in preferred embodiments of the present invention, a doped first polysilicon layer is grown substantially thicker than a less doped (or non-doped) second polysilicon layer so that the average doping level resulting from the summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of the dopant from the first intermediate layer to the second additional layer in the thermal treatment. This allows the dopant to be prevented from reaching the surface during a subsequent thermal treatment, without significantly changing the average doping level in the thermal treatment. In other words, the substantially thinner second polysilicon layer provides a barrier during thermal treatment, but does not significantly change the average doping.

Beinglass does not teach or suggest depositing polysilicon layers such that a doped polysilicon layer is substantially thicker than a non-doped polysilicon layer. In fact, Figures 4-7 of Beinglass disclose depositing doped polysilicon layers that are thinner than non-doped polysilicon layers. Furthermore, Beinglass is directed to producing a doped polysilicon layer that has better step coverage, and achieves this by alternately depositing doped and non-doped polysilicon layers. As explained in Beinglass, this produces better step coverage because the non-doped polysilicon layers are deposited more uniformly so as to more quickly fill low areas such as trenches. In other words, the non-doped layers act to fill low areas that would be filled much slower by the deposition of a doped layer. Thus, in the process of Beinglass, if the non-doped polysilicon layer was made substantially thinner than the doped polysilicon layer (as in the present invention), the process would not achieve the better step coverage that is desired.

Accordingly, it is submitted that Beinglass actually teaches away from growing a doped polysilicon layer that is substantially thicker than a less doped (or non-doped) polysilicon layer. Applicant believes that the differences between the Beinglass and the present invention are clear in amended claims 1 and 15, which set forth in-situ deposition and doping methods according to embodiments of the present invention. Therefore, claims 1 and 15 distinguish over the Beinglass reference, and the rejections of these claims under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a) should be withdrawn.

As discussed above, claims 1 and 15 distinguish over the Beinglass reference. Furthermore, the claimed features of the present invention are not realized even if the teachings of Alspector and Wang are incorporated into Beinglass.[1] Neither Alspector nor Wang teaches or suggests the claimed features of the present invention that are absent from Beinglass. Thus, claims 1 and 15 distinguish over the Beinglass, Alspector, and Wang references, and thus, claims 2-14 and claim 16 (which depend from claims 1 and 15, respectively) also distinguish over the Beinglass, Alspector, and Wang references. Therefore, it is respectfully submitted that the rejections of claims 1-16 under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a) should be withdrawn.

Claims 25-31 have been added by this amendment, and are provided to further define the invention disclosed in the specification. Claims 25-31 are allowable for at least the reasons set forth above with respect to claims 1-16.

In view of the foregoing, it is respectfully submitted that the application and the claims are in condition for allowance. Reexamination and reconsideration of the application, as amended, are requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is invited to call the undersigned attorney at (561) 989-9811 should the Examiner believe a telephone interview would advance the prosecution of the application.

Respectfully submitted,

Date: October 11, 2001

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[1] Applicant makes no statement as to whether such a combination is even proper.

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APPENDIX

IN THE SPECIFICATION:

"CROSS-REFERENCE TO RELATED APPLICATIONS" (page 1, line 6):

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims priority from prior European Patent Application No. 97-830603.3, filed November 14, 1997[, the entire disclosure of which is herein incorporated by reference].

IN THE CLAIMS:

1. (Amended) An in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device, said method comprising the steps of:

growing a first intermediate layer of in-situ doped polycrystalline silicon with a first thickness and a first doping level; and

growing a second additional layer of polycrystalline silicon with a second thickness and a second doping level that is lower than the first doping level,

wherein the first thickness is substantially greater than the second thickness so that the average doping level resulting from a summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of doping atoms from the first intermediate layer to the second additional layer.

7. (Amended) The in-situ deposition and doping method as defined in claim 1, further comprising the step of:

performing a subsequent thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level resulting from the summation of the first intermediate layer and the second additional layer is not significantly changed by the thermal treatment.

11. (Amended) The in-situ deposition and doping method as defined in claim 10, further comprising the step of:

performing a subsequent thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level resulting from the summation of the first intermediate layer and the second additional layer is not significantly changed by the thermal treatment.

12. (Amended) The in-situ deposition and doping method as defined in claim 10, further comprising the step of:

performing a subsequent re-oxidation treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level resulting from the summation of the first intermediate layer and the second additional layer is not significantly changed by the re-oxidation treatment.

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15. (Amended) An in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device, said method comprising the steps of:

growing a first intermediate layer of in-situ doped polycrystalline silicon with a first thickness and a first doping level;

growing a second additional layer of polycrystalline silicon with a second thickness [doping level that is lower than the first doping level]; and

performing a re-oxidation thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the second additional layer is substantially not doped, and

the first thickness is substantially greater than the second thickness so that the average doping level resulting from a summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of dopant from the first intermediate layer to the second additional layer in the re-oxidation thermal treatment.

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